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DISEASES OF BEES

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DISEASES OF BEES

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1948

FOREWORD

THE subject-matter of this bulletin on diseases of bees, now revised and expanded by the Bee Department of Rothamsted Experimental Station, was formerly printed as part of Bulletin No. 9 (Bee-keeping), the current edition of which now deals only with the management of healthy colonies of bees.

Ministry of Agriculture and Fisheries,

September, 1945.

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DISEASES OF BEES

BROOD DISEASES

The brood of the honeybee, during its development from the egg to the transformation of the pupa, is subject to a variety of diseases, all of which have a weakening effect on the colony as a whole. The degree of weakening ranges from the loss of a small proportion of the total population of the hive, in a mild attack of Chalk Brood, for example, to the complete collapse and eventual death of the colony in the case of an infection with American Foul Brood. This disease in particular is responsible for considerable losses to bee-keepers every year, and a single neglected case may become a source of infection for any other bees which are kept in the neighbourhood.

It is therefore very desirable that every bee-keeper should have a working knowledge of the main features of the more common brood diseases and that he should at least be able to distinguish between healthy and diseased brood, even if he cannot make a diagnosis of the precise cause of the trouble without expert help.

A careful inspection of the brood should be made during all manipulations involving the removal of combs from the hive, or their rearrangement. A casual glance at the *amount* of brood present is not enough and both the sealed and the unsealed cells should receive their share of attention. If anything suspicious is seen it should be investigated at once, since failure to do so may result in the spread of disease to other colonies in the same apiary or to neighbouring apiaries. It is necessary to point out, however, that the first signs of a brood disease are not easily detected except at close quarters, especially if the combs are old and dark in colour, and bee-keepers who require spectacles for reading purposes should not neglect to use them under the bee-veil when making an examination of the brood chamber.

FOUL BROOD

The term " Foul Brood " includes two bacterial diseases of the honeybee, one known as American Foul Brood, and the other as European Foul Brood. The names bear no relation either to the origin or to the geographical distribution of the two diseases; they came into use after research work in America had shown that the bacteriology of the " Foul Brood " then being investigated there differed from that which had been described from another case of " Foul Brood " investigated some years earlier in England.

American Foul Brood is the most widespread and the most destructive of the brood diseases which occur in Great Britain. Cases have been reported from all the counties of England and Wales (including the Isle of Wight), from parts of Scotland, and also from Northern Ireland and Eire. It is particularly prevalent in the south and south-west of England, in the South-east and in the West Midlands. The full incidence of the disease is, however, not yet known, and wherever bees are kept the bee-keeper should be on his guard against the spread of American Foul Brood from undiscovered cases nearby, or from infection imported into his locality from elsewhere.

European Foul Brood is less common, but where it does occur it often spreads rapidly throughout the apiary, and for this reason may prove difficult to eradicate even when control measures are applied promptly and energetically.

American Foul Brood

Cause. This disease is caused by a microscopic spore-forming organism known as *Bacillus larvae*. Spores from some previously existing source of infection, such as contaminated honey robbed from another colony already weakened by the disease (*see* below, under " Spread," p. 3), become mixed with the brood food fed to the young larva by the nurse bees. The spores germinate within the body of the larva and give rise to bacteria, which then proceed to grow and multiply at a great rate, feeding at the expense of the tissues of the larva itself. Soon after the larva has been sealed over in its cell by the bees working on the comb, it collapses and dies. When this happens the food supply of the bacteria is no longer maintained, and their growth and multiplication ceases. Each bacterium then transforms itself back into the spore stage. The spores so produced, now many times more numerous than those which caused the larva to become infected in the first place, remain dormant until some of them, in their turn, after being distributed throughout the hive by house-cleaning bees attempting to clean out the cell containing the dead remains of the larva, are enabled to complete their life cycle by being mixed with the brood food of another larva. The whole process then starts again and is repeated indefinitely. More and more larvae become infected, the proportion of the brood which emerges gradually becomes less and less, and sooner or later the colony dies out from sheer lack of enough bees to keep it going.

The spores are very resistant to exposure to extremes of heat and cold, and to disinfectants. They will retain their powers of germination for many years if left undisturbed in old combs kept in store, or in derelict hives, skeps or boxes.

Symptoms. The collapse of the infected larva takes place within the sealed cell, after the cocoon has been spun, and is therefore not to be seen merely by looking at the surface of the comb. Associated with this collapse, however, are changes in the appearance of the cell capping, and these changes are of primary importance as a first indication of the presence of abnormal brood in the hive (see Fig. 2). The capping becomes moist and darkens in colour, and as the larva continues to shrink the capping is drawn down into the mouth of the cell, its originally slightly-domed shape becoming reversed. The worker bees nibble holes in the sunken capping and eventually remove it altogether, leaving an open cell containing the remains of the dead larva (see Figs. 3 and 4).

The collapse of the larva is accompanied by a change in colour from the normal pearly-white of healthy brood to a creamy brown, light at first, then becoming darker. The consistency of the larval remains is very slimy at this stage and if a match-stick is thrust through the sunken capping into the cell, twisted round and then withdrawn, the slimy mass will pull out in the form of a glistening, mucus-like, brown thread or " rope " (Fig. 5). The " rope " may be light or medium brown, according to the length of time which has elapsed since the death of the larva, and it has an opaque, milky appearance. It is therefore very aptly described as being coffee-coloured. The ropy condition is succeeded by a tacky stage, as the larval remains in the cell gradually dry up, and the colour changes to dark brown. Further drying leads to the final stage, which is a very dark brown, rather rough scale lying

on the lower side of the cell, and extending from just behind the mouth of the cell right back to the base.

The brood combs of a colony in which the disease has become established often have a patchy appearance. This is due to the presence of dead larvae in all the various stages of collapse, from the ropy condition in cells with dark, sunken, or perforated cappings, to the dry scales lying in open cells whose cappings have been chewed away completely by the bees. Unsealed brood and sealed cells with normal cappings (containing brood which has escaped infection) continue to be seen for some time, but as the queen does not lay in the cells containing scales, these patches of brood gradually become constricted to small groups of cells scattered irregularly over the face of the comb.

The scales cannot be distinguished properly by a casual glance at the comb at right angles to its surface, since the cells slope slightly downwards towards the midrib, and their lower sides, on which the scales invariably lie, are partially hidden from view. They are, however, quite easy to see if the comb is held in the manner shown in Fig. 6. Here the bee-keeper is standing facing the light and is holding the frame by the lugs and side bars. He is looking down at the comb from above and the light which falls into the mouths of the cells is reflected back into his eyes. In this way the whole of the face of the comb can be scanned rapidly, from side to side and from top to bottom. The scales catch the light on their rough surfaces and can easily be seen, even when their colour is almost matched by that of the comb itself. In the old comb shown in the illustration empty cells would appear as dark cavities from which little or no light is reflected.

The scales stick very tightly to the lower sides of the cells and can be removed by the bees only with great difficulty. They persist in combs from colonies which have died out as a result of American Foul Brood and are therefore valuable as evidence of the cause of death. Whenever a colony dies out the combs should be scanned for the presence of scales, and if anything resembling them is found a sample comb should be submitted for examination by a disease expert. The remaining combs should be left in the hive, and the latter made absolutely bee-tight pending the receipt of a report on the condition of the sample.

Spread. The spread of the disease *within* the colony has already been described. The activities of the bees during their attempts to clean out the cells containing the remains of the dead larvae lead to the distribution of the spores throughout the hive. *The honey stored in the brood combs or in the supers inevitably becomes contaminated with the spores and is therefore a source of infection for any colony whose bees gain access to it. This fact is of great significance in considering the spread of the disease from one hive to another, and from one apiary to another.*

If the bee-keeper fails to notice the presence of the disease, or if he neglects to take steps to deal with it, the colony will become so weak that it will be unable to defend itself should it be attacked by robber bees from strong colonies nearby, either in the same apiary or in that of a neighbouring bee-keeper. The robbers will take back with them all the honey they can find and some of it will be used in the preparation of brood food for feeding their own larvae. These larvae, fed on the brood food contaminated with the spores from the stolen honey, will become infected; and from this point the whole

process of a decline in strength, followed by robbing and further spread of the disease, may be repeated. Thus it comes about that a strong colony—one capable of robbing a weak one—may be the first to bring American Foul Brood into an apiary from some source of infection elsewhere.

The exposure of contaminated honey by the bee-keeper may also lead to the spread of the disease. If honey in the super combs of an infected hive is extracted, for example, the extractor becomes contaminated, and bees which find their way into the extracting shed may carry the spores with them back to their own hives. The wet super combs after extraction will also be a source of infection for any colony to which they are given for cleaning up before storage for the winter. For this reason it is wise to label all supers with the number of the hive from which they came, and to put them back on the same hive for cleaning. Then, if any disease is discovered during the examination of the brood combs prior to the autumn feeding, the supers from that hive can be located and dealt with accordingly.

Failure by the bee-keeper to recognize the disease when the first signs of trouble appear may lead to its spread in other ways. He may transfer combs of brood, or of honey, to other colonies which require strengthening and by this means spread the disease directly throughout his apiary. His appliances may become contaminated, too, and act as intermediate agents carrying spores in smears of honey and propolis.

Bees issuing in a swarm from an infected colony—a strong one, for instance, which has picked up the disease by robbing—will take contaminated honey with them, which may infect the brood produced after the swarm is hived, especially if drawn combs are used in which the queen can lay eggs without delay. Young bees coming out for a play-flight after being engaged in cell-cleaning operations in the hive, and drifting back into other hives nearby, are also potential agents for the spread of the disease.

American Foul Brood, like other bee diseases, may also be spread from one locality to another by the purchase of bees from an infected source, or by the sale of second-hand combs and equipment. When buying bees, therefore, care should be taken to deal with a reputable breeder; or a personal inspection of the colonies, preferably in the presence of a disease expert, should be made before making the purchase.

Treatment. No cure, in the strict sense of the word, is known for American Foul Brood. Until one has been discovered *and has been proved to be completely reliable in the hands of the average bee-keeper, control of the disease must rely on prompt recognition, before it has time to spread to other colonies, followed by the complete destruction by fire of all the contents of the hive, and the subsequent decontamination of the hive itself.*

In special cases it may be possible to save the bees by stupefying them quickly with the fumes of burning saltpetre and allowing them to climb on to new frames of foundation as they revive. Precautions must be taken, however, against killing the bees outright with the fumes, and against the transfer of contaminated material during the operation. It should never be undertaken, therefore, except under expert guidance and no full description of the method can be given here. In any event, the contents of the hive other than the bees must be destroyed, since no reliable means of disinfecting combs has been devised.

European Foul Brood

Cause. This disease is the result of a bacterial infection of the young larvae which causes their death when they are about four days old. The bacteria present in the dead larvae show a variety of form, and the picture presented under the microscope, as well as the symptoms seen in the comb, may vary between one larva and another, or between one case of disease and another. The characteristics of the disease are therefore not so uniform and regular as those of American Foul Brood.

Though the death of the larvae is caused by bacterial action, recent research work in Switzerland, where the disease is very prevalent, indicates that the organism which is responsible may be found in apparently quite healthy colonies, and that some other factor, the nature of which remains to be discovered, may determine the actual onset of a state of disease in the brood.

Symptoms. Shortly before death the infected larva becomes restless and wanders about inside its cell instead of remaining in the normal coiled position characteristic of a healthy larva of the same age. Consequently, when it dies, about four days after hatching from the egg, it is found in an unnatural attitude—across the mouth of the cell, twisted spirally around the walls, or stretched out lengthwise from the mouth to the base (see Fig. 7). The plump, pearly-white appearance is lost; the larva collapses as though it had been melted, it turns yellowish-brown and eventually dries up to form a loosely attached, brown scale. In the scale the tracheae of the larva can sometimes be seen as a network of glistening threads. The consistency of the recently dead larva varies: it may be sticky or porridge-like, but not ropy. The smell of the larval remains also varies, both in intensity and in quality: it may be exceedingly foul or merely sour, depending upon the type of bacterium which has become established after the initial infection.

The disease is essentially one of the *unsealed* brood but some of the infected larvae may survive until their cells are sealed, in which case there may be a few sunken or perforated cappings to be seen.

Spread. Within the hive the disease may spread to such an extent that there is a serious reduction in the number of workers emerging from the combs, followed by the decline and death of the colony. In other cases, after an appearance of the disease in the spring or early summer, the symptoms may gradually disappear during the course of the season, until no visible signs are left by the autumn. A reappearance is, however, likely in the following spring, and in the meantime the disease may have spread to other colonies in the apiary, either in an active, visible form, or in a dormant form which may become active at a later date.

In general, the factors already considered in connexion with the spread of American Foul Brood apply also to the spread of European Foul Brood. Two points of difference should, however, be mentioned. First, the scales of European Foul Brood are easily removed by the bee and therefore do not persist as visible evidence of the disease, though the combs may nevertheless be capable of carrying it. Secondly, some larvae with a mild infection of European Foul Brood may pupate and develop into workers whose bodies are already contaminated with bacteria from the cell in which they were reared; so it is likely that the drifting of young bees from one hive into another may account for the rapidity of spread which often occurs in apiaries where the disease has made its appearance.

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Symptoms. The cappings are not affected by the death of the larvae within the cells, but they are afterwards removed by the bees and it is then that the chalky-white appearance of the dead brood can be seen by the bee-keeper (Fig. 8).

The larvae are transformed by the growth of the mould into white objects which look like small mummies. These fill the cells completely at first and have a rather spongy or rubber-like consistency. Later they shrink and become tough and rather fibrous. At this stage they are quite loose in their cells and can easily be removed by shaking the comb. Sometimes the mummies lose their white appearance and assume a greenish-brown or black colour; this is due to the formation by the mould of cysts containing spores, but it happens only when both male and female spores have germinated in the same larva to form growths of both sexes.

Spread. Chalk Brood must be regarded as a contagious disease and it can be spread by the transfer of affected combs from one colony to another. The spores of the mould can, however, remain in a hive without doing any harm, becoming active only when conditions are suitable for them to develop. In well-kept apiaries these conditions either do not occur, or exist only temporarily, so that the probability of the disease becoming established is remote.

Treatment. In mild cases the colony may overcome the attack without any assistance from the bee-keeper. With more serious attacks the worst combs may have to be destroyed and the bees transferred to a fresh hive fitted with clean drawn comb or foundation. The old hive should then be scraped clean and treated with a blow-lamp, as for Foul Brood (see page 6) before being used again. If the disease persists after the bees have been transferred, it is recommended that the colony be requeened with a queen of a different strain, whose progeny may be able to overcome the attack of the mould where the others failed.

Dampness in the hive should be avoided, and any affected colonies which are exposed to damp conditions should be removed to a drier situation. Strong colonies with vigorous queens, kept in sound, well ventilated hives are the best form of defence against the disease.

STONE BROOD

This disease is caused by a mould belonging to the genus *Aspergellus*. The mould attacks the brood transforming the larvae into hard stone-coloured objects which are found lying in open cells. Adult bees may also be attacked and killed by the mould. The disease is rare in this country, only one case having been definitely recorded. A sample comb from any suspected case of the disease should be sent for examination without delay (see p. 25). Since some of the *Aspergellus* moulds can cause trouble in the respiratory passages in man, care should be taken not to inhale any of the dust (spores) with which the dead brood may be covered.

ADDLED BROOD

This is a common disease which at first sight may be mistaken for American Foul Brood, since it is the sealed brood which is affected, and moist, sunken, or perforated cappings are usually to be seen. The dead brood maintains its shape and outline to some extent, however, and the contents of the affected cells are never ropy.

Cause. The condition is the result of some defect in the egg which does not become apparent until the larva has completed its development up to the pre-pupal or pupal stage. (Occasionally cases are reported in which the egg never matures and fails to hatch, but whether this phenomenon is an extreme form of the Addled Brood described here is not known.) The queen which lays the eggs is therefore to be regarded as the cause of the trouble.

Symptoms. Both worker and drone brood may be affected. The brood normally dies in the pre-pupal or pupal stage, that is, after the cells have been sealed. Combs of sealed brood taken from diseased colonies often show a " pepperbox " appearance due to the patchy arrangement of the sealed cells. The dead pre-pupae are soft and moist, and are difficult to remove from their cells without damage. They are frequently greyish in appearance and of a rather shapeless sac-like form; or the head and thorax may already be visible, though somewhat shrivelled and contrasting with the lighter and broader abdominal parts. They shrink to form rather moist, slightly sticky, brown scales, but these are never so adherent as those of American Foul Brood. One of the outstanding features of the disease is that advanced pupae and bees apparently almost ready to emerge are found dead in their cells. In such cases the pupae are often of small size, with the abdominal parts much reduced in relation to the size of the head and thorax. The bees usually attempt to remove the dead brood by pulling off the cappings and chewing the cell contents.

Treatment. The queen should be destroyed and replaced with one which produces normal brood—preferably one reared in another colony, since daughter queens reared in the affected colony may lay eggs carrying the same defect as those laid by the parent queen.

As the disease is not contagious and as the bees will gradually remove the dead brood from the cells, there is no need to destroy any of the combs, or to take any special precautions when manipulating affected colonies. The appearance of Addled Brood in several colonies in the same apiary would suggest that the queens are derived from a common stock, and that requeening with a different strain of bee would be advisable.

SAC BROOD

Cases of Sac Brood are reported occasionally in Great Britain, but there is some doubt as to whether the disease does actually occur here. It is believed to be caused by a virus. An infected larva becomes fully grown, but dies after its cell has been capped. It assumes a sac-like form with a tough skin, which is filled with a watery, granular fluid. The scale which forms later is loosely attached to the cell and is easily removable by the bees.

No remedy for the disease has been found, but it seldom becomes serious and usually passes away without treatment.

ABNORMAL CONDITIONS OF THE BROOD DUE TO FACTORS OTHER THAN DISEASE

CHILLED BROOD

This may be caused in a number of ways and is very often the result of carelessness or inexperience on the part of the bee-keeper. For example, hives may be opened too early in the spring, and the combs left exposed to a cold wind during the examination; or the brood may be " spread " prematurely by the insertion of empty combs into the brood nest in the hope of stimulating the queen to increase her egg-laying.

Chilling may also occur if there is a serious loss of bees caused by disease, or by poisoning (see p. 23), when the remaining bees may be too few to cover the brood. A similar lack of balance between the amount of brood and the number of bees may occur if a prolonged spell of warm weather in the spring is followed by unseasonable weather later; the bees raise more brood than they can cover adequately in the event of a sudden cold period, the arrival of which causes them to contract and leave some of the cells unprotected.

Young coiled larvae which have been chilled often turn a glistening black and are difficult to see unless the brood combs are new; in old combs their colour matches that of the dark interior of the cells. Older chilled larvae become greyish in colour. The sealed brood may show moist, sunken and perforated cappings, as in American Foul Brood, but the cell contents are never ropy.

The trouble will usually be cleared up by the bees themselves, but in severe cases the affected combs should be replaced by clean ones, and either rendered down for wax or kept in a dry place for use again later when the dead brood has become shrivelled and easy for the bees to remove.

STARVED BROOD

Colonies which have produced a large amount of brood in the spring may find themselves short of food during bad weather in the early summer. Some of the brood may then have to be abandoned: egg laying ceases, young larvae are often eaten by the bees and pupae may be found thrown out on the ground in front of the hive. Starved or neglected brood may also result from such operations as artificial swarming and certain systems of swarm control, if they are carried out thoughtlessly.

It should be realized that in our variable climate bees sometimes run short of stores in May or early June, or even later, and a supply of sugar should be kept available for feeding in such an emergency.

NEGLECTED DRONE BROOD

The presence of a drone-laying queen or of laying workers leads to the production of irregular patches of drone brood. If the colony is weak, many of the larvae and pupae reared in worker cells are small and undernourished. If this state of affairs is allowed to continue, the brood becomes neglected by the bees and chilling causes death and subsequent decomposition. The combs have an untidy appearance due to scattered groups of cells with raised and irregularly dome-shaped cappings; many of the latter may be partially torn away, leaving the heads of the dead drones exposed to view. The decomposing larvae become soft and often brown in colour, and eventually they dry up to form dark masses sticking to the sides of the cells.

The obvious remedy is to requeen or to unite the remaining bees with another colony, but the inexperienced bee-keeper may overlook the real cause of the trouble—the lack of a good fertile queen—and recognize only the more obvious decomposition of the brood, with its superficial resemblance to Foul Brood. Badly distorted combs and those containing a large amount of dead brood are best replaced by clean drawn comb.

Comparative Summary of the Chief Symptoms of the Four Brood Diseases commonly occurring in Great Britain

	American Foul Brood	European Foul Brood	Chalk Brood	Addled Brood
Time of Death	In pre-pupal stage or shortly after pupation—*after* cell has been sealed.	Usually about 4 days after hatching from egg; essentially disease of *unsealed* brood.	After sealing.	Pre-pupal or pupal stage; often just before pupae are due to emerge.
Cappings	Sunken, dark in colour, often moist and perforated.	Usually none visibly affected; if larvae die after sealing — cappings dark, sunken, and perforated as in A.F.B.	Not affected, but later removed by the bees.	Variable; may be dark and moist, often removed by bees.
Position of dead Brood in Cell	Always in lower angle; stretched out along length of cell.	May occupy any position; often twisted spirally; collapsed or melted appearance.	Normal.	Normal.
Colour Changes	From light creamy brown to dark coffee-coloured; eventually almost black.	Variable; yellow-brown to brown or dark brown.	Yellowish white at first (before removal of capping), then chalky white; may become greenish-brown or black.	Greyish, becoming brown.
Consistency	Slimy; marked ropiness at coffee-coloured stage, then becoming tacky.	Soft, sticky or porridge-like; no marked ropiness.	Spongy or rubber-like mummies; later tough and fibrous, and easily removed from cells.	Soft and moist, difficult to remove intact from cells.
Scale	Hard, dark brown and adherent; always in lower angle of cell.	Brown; position variable; tracheae often visible; easily removed.	—	Moist, sticky and brown; easily removed.

FOUL BROOD DISEASE OF BEES ORDER, 1942

This Order, made by the Minister of Agriculture and Fisheries on the recommendation of the Bee Disease Advisory Committee, empowers County Agricultural Executive Committees to investigate suspected outbreaks of Foul Brood disease and to require the destruction of bees in affected colonies with their combs and quilts, and the adequate disinfection of hives, appliances and apparatus if, after laboratory examination of a sample comb or combs, the presence of foul brood disease is confirmed.

If a bee-keeper suspects that a case of Foul Brood in his apiary has been contracted from an unknown source of infection in his neighbourhood, or if he suspects that a case of Foul Brood, from which his bees may contract disease, exists in his neighbourhood and is not already being dealt with, he should at once inform the County Agricultural Officer of his County Agricultural Executive Committee. The address can be ascertained from the County Council Offices, or from notices appearing in the advertisement columns of the local newspapers. An inspection by an appointed officer of the bees in the area concerned will then be arranged.

DISEASES OF ADULT BEES AND THEIR TREATMENT

Our knowledge of the diseases of adult bees has made great progress since the 1914-1918 war, up to which time little was known of the nature of the maladies which affected bees from time to time. The prevalence and widespread nature of the disastrous malady known as " Isle of Wight disease " about 1919 greatly stimulated research work in this country and, as a result, several distinct maladies, exhibiting many symptoms in common, have come to be recognized; so that the designation " Isle of Wight disease " has long ceased to be justified and must give place to names indicating more exactly the specific nature of the various complaints.

Since 1939, surveys have been carried out to determine the incidence and distribution of the various diseases of adult bees in England and Wales. The result of all this research and the general adoption of the movable comb hive is that we are now in an incomparably better position to gain and maintain control over these diseases than we have ever been before.

In the following pages each of the diseases of adult bees known to occur in this country is discussed and the most up-to-date method of treatment explained.

ACARINE DISEASE

This disease is very common and occurs in every county in the British Isles. At the time of writing (1945) about one out of every six of the colonies of bees in England and Wales is suffering to a greater or lesser extent from this disease, and the loss of bees and honey annually as a result of its depredations is tremendous. This is all the more deplorable since, as a result of research work carried out since 1918, such loss is now almost entirely preventable.

Cause. Acarine disease is caused by the invasion of the thoracic tracheal system (breathing tubes) of the adult worker, drone, or queen bee by a parasitic mite, *Acarapis woodi* Rennie. Its life-cycle is completed in the

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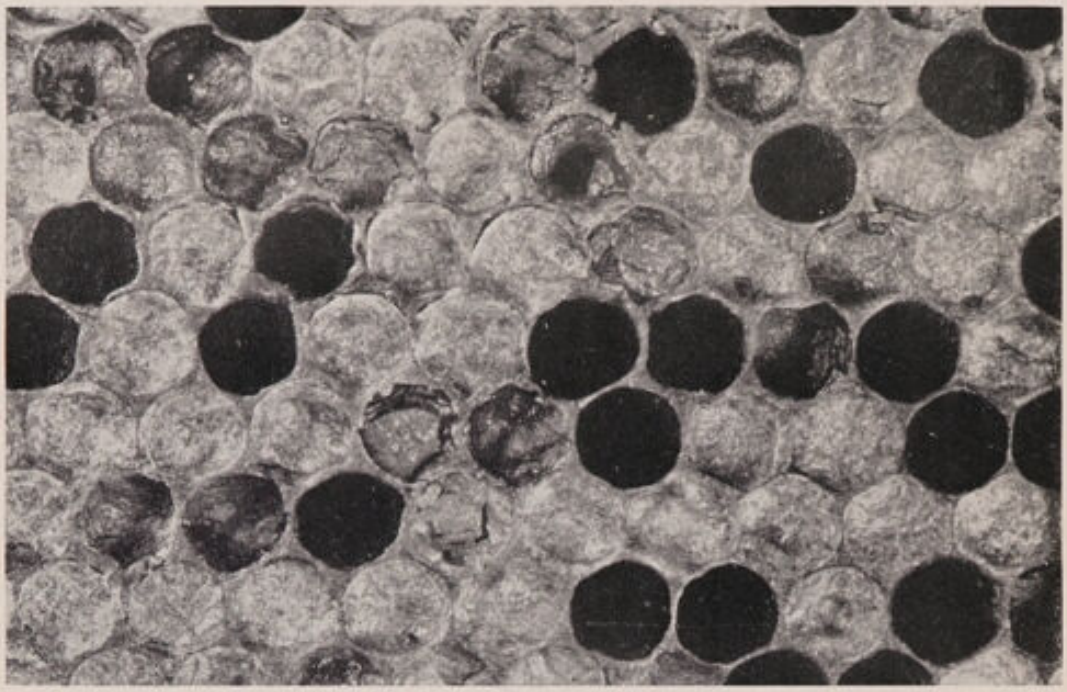

FIG. 3. AMERICAN FOUL BROOD. Note many sealed cells with dark, sunken or perforated cappings.

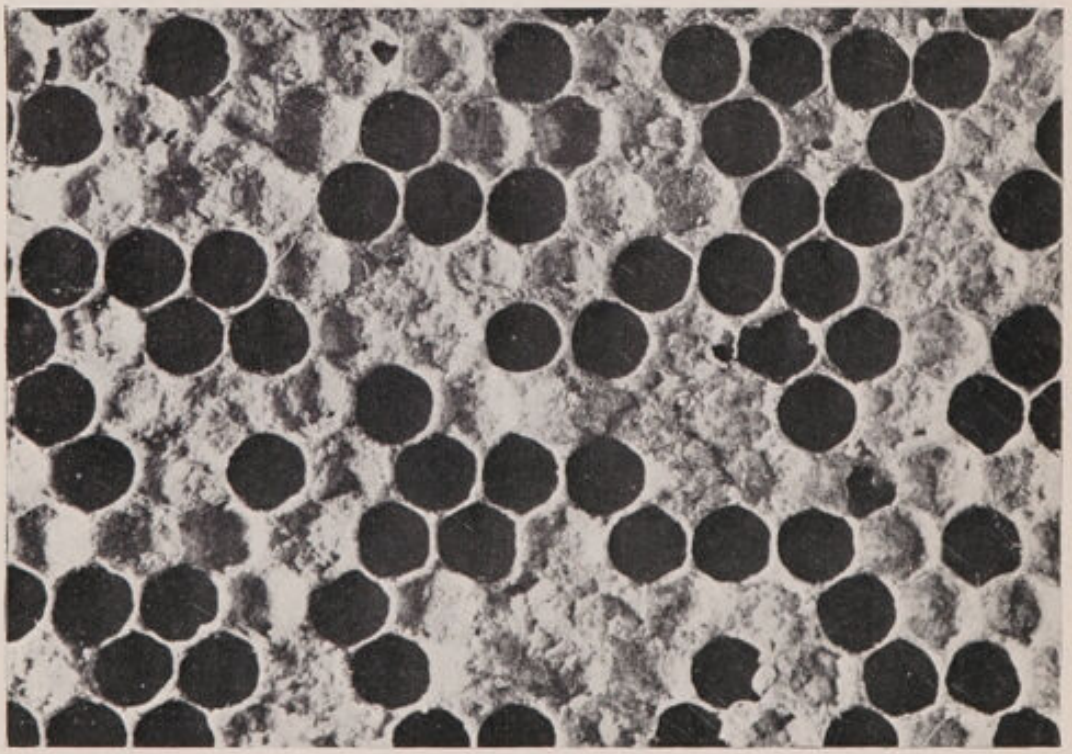

FIG. 4. AMERICAN FOUL BROOD. Many of the open cells have had their cappings removed by bees and contain scales (not visible in the photograph).

FIG. 5. AMERICAN FOUL BROOD. The "ropiness" test.

FIG. 6. AMERICAN FOUL BROOD. How to examine comb for the presence of scales (see also p. 3).

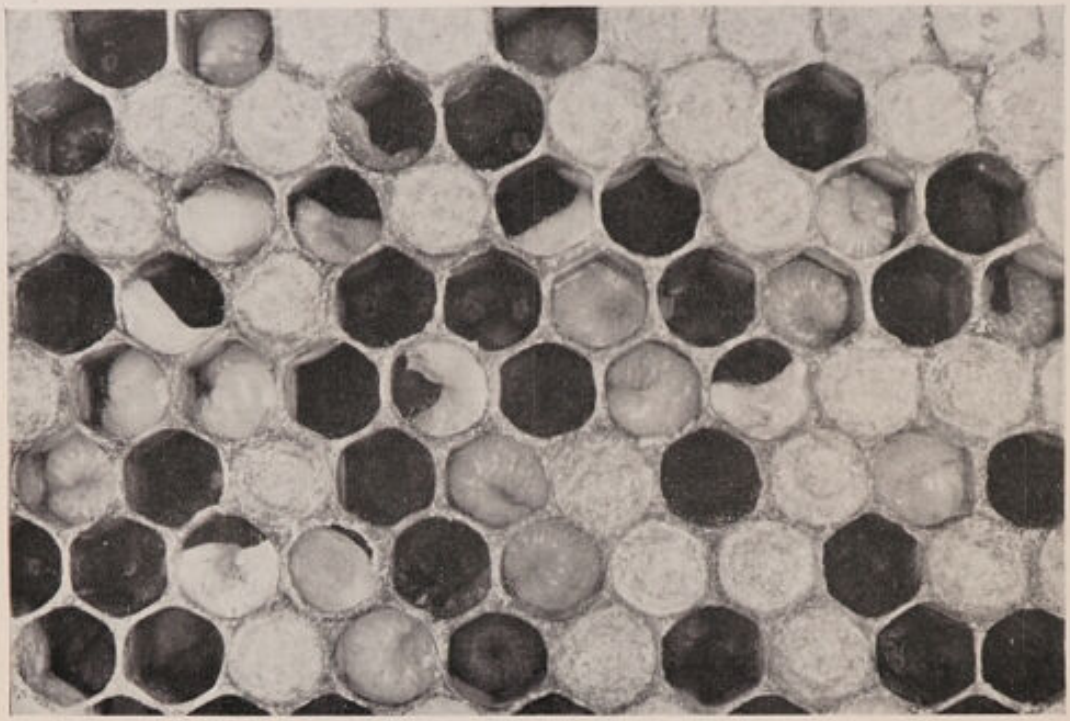

FIG. 7. EUROPEAN FOUL BROOD. Note the unsealed larvae in various stages of collapse.

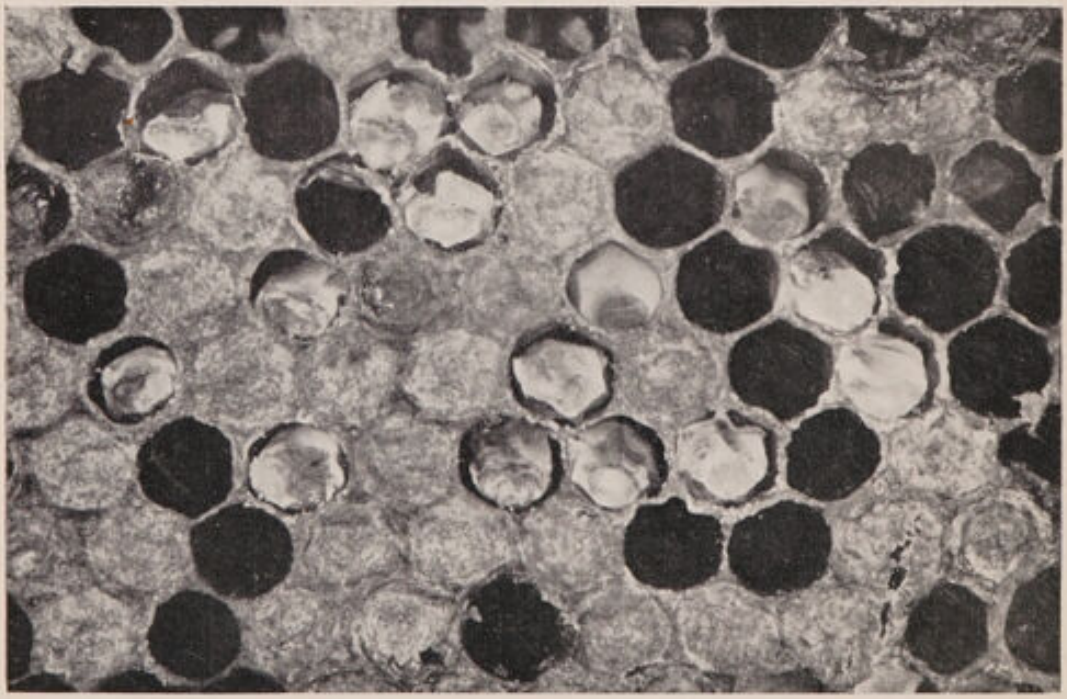

FIG. 8. CHALK BROOD. Showing the white "mummies" in cells uncapped by the bees.

[Figs. 1–8 by courtesy of Rothamsted Experimental Station.]

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Signs of Infection with Acarine Disease. Crawlers may appear after a period of confinement to the hive caused by unfavourable weather. These crawlers leave the hive fluttering their wings and often one or more wings are carried at an abnormal angle to the body, as if dislocated (the so-called "K-winged individuals"); frequently, the abdomen is distended. Falling from the edge of the alighting-board on to the ground these infected bees crawl away from the hive in all directions until, becoming chilled or exhausted, they climb to the tips of grass-stems or other herbage, or huddle together in small groups. When the percentage of infected bees within the colony is high, as frequently happens in the autumn and spring, mass crawling may occur, and thousands of bees in the condition described above may be found for many yards around the hive. Bee-keepers should keep a careful watch on their colonies not merely for crawlers, which only appear in the later stages of the disease, but also for other signs of debility, such as listlessness and inactivity among the older bees on fine days when bees from other colonies are flying hard.

It cannot be emphasized too strongly, however, that reliance on outward signs as evidence of the presence or absence of acarine disease is never to be recommended. The only reliable method of diagnosis is a microscopical examination by a competent person of the thoracic tracheae of each individual of a representative sample of 25-30 bees taken at random from the colony concerned. As many bee-keepers have neither the facilities nor the time to make such examinations and since it is impossible to arrange for regular annual or biannual examination of a sample of bees from every colony in this country, bee-keepers will be well advised to apply the methyl salicylate treatment described below to *each* of their colonies of bees *every* year as a precautionary measure against infection with acarine disease. Such treatment will do harm neither to the bees nor to their brood, nor will it cause robbing or taint the honey.

Treatment of Acarine Disease. There are three important methods of treating colonies of bees suffering from this disease: (1) the Manipulative method; (2) the Frow (or Modified Frow) treatment; (3) the Methyl Salicylate treatment. *In addition* it should be remembered that diseased colonies can easily be lost through lack of stores and feeding may be an essential part of the treatment, particularly in the spring. There is also danger of robbing if the colony is weak and the hive entrances of infected colonies should be reduced as necessary to guard against this. Perforated zinc, which allows of thorough ventilation, is ideal for this purpose.

Very often the queen of an infected colony is herself infected, particularly if she was reared in that colony and, since a healthy fertile queen will play a large part in overcoming the disease, requeening is strongly advised when possible. Since the mite gains access to the bee's tracheal system during the first few days of adult life, the queen should be raised and mated in a healthy colony and introduced into the infected colony only when she is laying, by which time she will be well past the critical age for infection and may be expected to be immune to this disease.

(1) Manipulative Method. As already stated, a bee can only become infected with Acarine disease during the first four or five days of adult life, after which it is immune from this disease. Also, the mite responsible for this

disease can only live outside the body of a bee for a few hours at most. *Any* system of management, therefore, which will separate the young bees for the first five days of adult life from *all* old infected bees will prevent these young bees from contracting the disease. By making use of this knowledge it is possible during the summer months to save something from a colony of bees which is so heavily infected as not to be worth while treating by any other method (see "Severe Cases" p. 17); it is, however, also necessary to have a healthy colony of bees or a nucleus available before the method can be applied.

Examine the diseased colony and remove all the combs of sealed brood. Shake or brush all the adult bees from these combs and give the latter to a healthy nucleus or colony substituting empty drawn combs in their place in the diseased colony. Thereafter, until the diseased colony becomes so weak as to be liable to be robbed and of no further use, repeat this operation every 18th-20th day.

It is, of course, essential to see that *all* the bees are removed from these combs before transferring them to the healthy colony. If necessary, a little dilute syrup can be given to the diseased colony from time to time to encourage brood production.

The healthy nucleus or colony to which the sealed brood from the diseased colony is given soon becomes very strong and is particularly liable to swarm as a result of the unnatural proportion of young bees in the population. It will probably be found to be desirable to take a nucleus away from it.

As soon as the diseased colony becomes of no further use because it has grown too weak, it must be destroyed. After storage for a few days the combs, with any stores that they may contain, can be given to a healthy colony without fear of infecting the latter with Acarine disease.

(2) The Frow Treatment. The Frow treatment should only be applied between the end of October and March of the following year, when temperatures are relatively low and the bees almost completely confined to the hive. If applied during the warmer months when the bees are flying, robbing is almost certain to be induced. On the whole this treatment is best confined to the two months, November and February. The most suitable time to commence the treatment of a colony, whether in autumn or spring, is when a day on which the bees have been flying is followed by frosty weather with a prospect of the cold continuing for a week or so. The entrance to the hive to be treated should be reduced to about a double bee-space, preferably by the use of perforated zinc which allows of good ventilation, and, should the weather become mild during or soon after treatment, a close watch must be kept for any signs of robbing. If the weather continues to be cold after treatment, no activity may be observed for some days or even weeks, but on no account should the hive be opened on the assumption that the colony is dead.

The only equipment necessary is a small pipette graduated in minims (or with a mark engraved upon it at the 30 minim level), some pieces of flannel or absorbent cotton-wool each about 4 in. square, and a bottle of Frow mixture. The pipette and, if the bee-keeper is not accustomed to mixing solutions, the Frow mixture, should be obtained from a reliable chemist.

FROW MIXTURE

Nitrobenzene	2	parts by volume
Safrol	1	
Ligroin (or ordinary petrol) ...	2	

"Special" brands of petrol of high volatility or special mixtures should not be used. Note that the mixture is poisonous and highly inflammable and must be handled with care.

MODIFIED FROW MIXTURE

Unfortunately owing to present conditions Safrol is in short supply, but it has been found that the following mixture containing methyl salicylate instead of Safrol can be used in its place with good results. Experience seems to indicate, however, that treatment with the modified Frow mixture is not quite so effective as that with the original Frow mixture containing Safrol.

Nitrobenzene	6	parts by volume
Methyl Salicylate	2	
Ligroin	5	

APPLICATION. The method of applying the Frow mixture or the modified Frow mixture is as follows:

Distribute half a drachm (30 minims) of the mixture drop by drop over the flannel or cotton-wool pad. This pad is then either placed directly on a piece of perforated zinc placed directly over the feed hole in the crown-board or quilt of the hive or, alternatively, pushed in through the entrance of the hive on a small piece of wire so that it comes to lie near the back of the floorboard. With the treatment over the feedhole a saucer or an empty jam jar can with advantage be inverted over the pad to ensure that the vapour passes downwards into the hive. When the treatment is from the floorboard it is a good idea to have previously placed an empty shallow super below the broodchamber. This super should not be removed until the colony is examined in the following spring.

Both methods of applying the Frow or modified Frow mixture are equally satisfactory, but in either case care must be taken not to disturb the cluster. The 30-minim dose is repeated on the same pad every other day until seven doses have been given. The pad should be left in the hive for ten days after applying the last dose and then removed.

Under conditions where it is not possible to pay repeated visits to the colonies to be treated, a single dose of 75 minims can be given and the pad removed 21 days later. In this event the treatment is best applied early in February.

(3) THE METHYL SALICYLATE TREATMENT. This method of treating a colony of bees either because it is known to be infected with Acarine disease, or as a precautionary measure against this disease, has in trials extending over several years proved to be extremely effective. It is essentially a treatment for the warmer months of the year, low winter temperatures greatly reducing its efficacy. This treatment, unlike treatment with the Frow mixture, has not been found to lead to robbing and it does not harm the brood, interfere with the normal working of the colony, or taint any honey that may be gathered during treatment.

The apparatus needed is simple and consists of a small glass specimen tube about 2 in. long and ¾ in. in diameter (an empty aspirin or similar bottle is equally satisfactory) or a small flattish tin such as used for cigarettes or meat extract cubes, together with a small quantity of absorbent cotton-wool and, of course, a supply of methyl salicylate which may be obtained from almost any chemist.

Application. The tube, bottle or tin should be fairly tightly filled with absorbent cotton-wool and as much methyl salicylate then poured on to this as can be absorbed. With tube or bottle, preparation of the apparatus will now be complete, but with a tin the lid should be closed and about half-a-dozen holes punched in it with a 1-in. round wire nail or similar instrument. The tube or bottle should then be laid on its side on the floorboard at the back of the hive. If a tin is used it must be placed, lid uppermost, in a similar position. The vessels containing the methyl salicylate should remain in place in the hive throughout the warmer months of the year, say from mid-March until early October. At intervals of three or four weeks their contents should be replenished and, if necessary, any wax or propolis removed from the evaporating surface or, where a tin is used, from the holes in its lid.

This treatment has proved to be so harmless to the bees and their brood, and so efficient in dealing with cases of infection with acarine disease, that all bee-keepers are strongly urged to make it a part of their apiary routine to keep methyl salicylate in each of their hives from March or April until September or October, whether or not they consider that their bees are likely to be suffering from this disease.

Severe Cases. It should be clearly understood that it is generally both useless and uneconomic to attempt to treat severely infected colonies of bees, i.e., colonies in which 50 per cent or more of the individuals are infected. The bees in such colonies should be destroyed as they are a source of considerable risk of spread of infection. The only exception to this rule that may reasonably be made is when a colony is found to be heavily infected in the early summer. The manipulative method described above may with advantage be applied to such a colony, the healthy nucleus employed in the treatment being treated with methyl salicylate continuously as an additional precaution.

NOSEMA DISEASE AND AMOEBA DISEASE

Cause. A microscopic animal parasite, *Nosema apis* Zander, consisting of a single cell which invades the cells lining the chyle stomach of the bees. *Nosema apis* belongs to the subdivision Microsporidia of the Protozoa, hence the name microsporidiosis which is sometimes used for the disease.

The rate of progress of nosema disease in a colony appears to depend upon concomitant factors and is frequently quite slow. Periodically, however, it becomes virulent and recent work on the Continent has offered a possible explanation for these outbreaks. In 1916 Maassen discovered that sometimes a small amoeboid parasite (*Malpighamoeba mellificae*) was to be found living in the Malpighian tubules (excretory tubes) of certain bees. This amoeba was for a long time regarded merely as a curiosity but gradually its importance came to be realized, and it is now believed that it has a connexion with

nosema and with the periodic outbreaks of spring dwindling. The amoebae develop and multiply within the cavity of the tubules; cysts are formed 24-28 days after the infection; these fill the tubules and pass from there into the faeces. Since the cysts require 3½-4 weeks for their formation, it is possible that a bee, weakened through infection with nosema and amoeba, will not live as long as this, so that the presence of amoeba, which is usually diagnosed by looking for the cysts, may in many cases be masked. It may therefore be assumed that amoeba disease is more widely distributed than previous search has indicated. The study of the effect of amoeba infection is made more difficult by the frequent presence of nosema in the same colony. It has been shown that a purely amoebic infection is often fatal, whereas a colony with both amoeba and nosema will sometimes recover. This may be explained by the quicker death of the individual bees due to the double infection so that the amoebae are prevented from forming the infective cysts.

The highest development both of nosema and amoeba occurs in the spring, just at the time when the over-wintered bees should be using their last energies in bridging the gap between the old and new generations. If the double infection with nosema and amoeba kills all the infected bees and if the number of these is large, then the fate of the colony is sealed. The frequently noted disappearance of the amoebae in the bees from May onwards is thus explained, since at the height of the nosema infection none of the bees will become old enough for the formation of amoeba cysts.

In Switzerland it has been found that the years with heavy losses due to spring dwindling appear to be those in which many samples sent for diagnosis show not only the presence of nosema but also of amoebic cysts. The evidence so far available suggests that the serious outbreaks of spring dwindling which have usually been ascribed to nosema are really due to the double nosema-amoeba infection. Swiss experience also shows that a severe attack of amoeba before May (with or without nosema) always tends to cause serious weakening or the death of the colony.

Symptoms. As this malady may be confused with acarine disease the following distinguishing features may be mentioned. Loss of power of flight has not been found to be a characteristic of nosema infection until the bees are about to die. In acarine disease it is usual for this symptom to appear a considerable time before death. Bees infected with nosema do not as a rule loiter in large numbers about the entrance of the hive, or gather in clusters on the ground as acarine infected crawlers do. They may be seen to come out, when *in extremis*, fall over on the ground, and lie upon their backs with their legs trembling or moving feebly.

Dysentery does not appear to be a primary symptom, but it may occur in a severe case of the double nosema-amoeba infection. Signs of dysentery may be difficult to find within the hives since the drops of faeces are eagerly lapped up by the bees; the outside of the hive may, however, be soiled by yellow crusty spots containing masses of spores and cysts.

Both nosema disease and amoeba disease, and of course cases of the double nosema-amoeba infection, have been found in widely separated parts of the British Isles in recent years. There is indeed good reason to believe that they are widespread in their distribution.

Treatment. No cure is at present known for either simple nosema disease or simple amoeba disease or for the double nosema-amoeba infection. Its depredations and spread can, however, be greatly diminished by the use of the following remedial and preventive methods.

(1) Great care should be taken to keep the hives and the surroundings of the apiary clean and dry. Cleanliness will not in itself secure immunity from disease, but dirty or damp surroundings lower the vitality of the bees and make them more susceptible to an attack. After an outbreak of disease the interior of all movable comb hives should be thoroughly charred with a painter's blow-lamp. The external surface should be scrubbed with a strong solution of chloride of lime before being repainted or re-oiled. *All* skeps, quilts, combs and dead bees should be burnt. The soil round the hives should be turned over and sprinkled with paraffin and then dug over and covered with quicklime.

(2) A supply of fresh clean drinking water (preferably rain-water collected from some bee-proof source) containing one ounce of common salt (sodium chloride) to every six and a quarter gallons of water, should always be available to the bees in a sunny and sheltered part of the apiary. The drinking fountain itself should be one of the modern types which can be readily cleaned. The spores of *Nosema apis* in water exposed to sunlight are killed in about three days. Undesirable sources of water should be treated with carbolic or lysol to make them unpalatable to bees, particularly if an outbreak of nosema disease has occurred in the apiary.

(3) It need scarcely be said that bee-keepers who live in districts that are free from disease should on no account purchase queens, colonies, nuclei, swarms or driven bees from an infected area. It should be pointed out that there are possibilities of nosema, amoeba, or double nosema-amoeba infection being brought into this country through the importation of queens from foreign countries. As a precautionary measure such queens should be transferred on arrival to a clean cage, and the attendant bees should be replaced by young healthy bees before introduction to a colony. The old cage together with any candy it may contain, and the attendant bees, should be burned.

(4) The attempted treatment of nosema and amoeba diseases by the feeding of syrup containing colloidal sulphur and various other substances must be mentioned for the sake of completeness, but such methods have not as yet been found to be effective when tested under controlled conditions and are, therefore, not recommended.

(5) Precautions should be taken against robbing, and also against dysentery by the provision of good dry conditions for wintering.

(6) Finally, it should be remembered that strong colonies are more likely than weak ones to combat either of these diseases successfully.

BEE PARALYSIS

Under the general heading of Bee Paralysis a number of diseases or complaints of the honeybee have been described under various names such as "Hairless Bees", "Black Robber Disease", "Little Blacks", "May Sickness", "Spring Dwindling Disease", etc., each of these diseases or complaints being, at least in their external symptoms, somewhat similar. It

is most convenient to consider the various forms of paralysis separately. It should, however, be clearly understood that other diseases of the honeybee, such as nosema, amoeba and acarine disease also result in some of the symptoms ascribed to paralysis.

The following classification of the various types of paralysis is somewhat tentative and several of the types described are very difficult to distinguish from one another, even when a complete history of the case is available.

Some of the forms of Bee Paralysis are very common and widespread in this country and cause serious losses to bee-keepers.

(1) **Infectious Type.** SIGNS. Trembling of the body and wings, and often sprawled legs and wings. Often most of the bees concerned become hairless, and have dark and greasy looking abdomens. In the early stages of this disease the bees collect at the entrance of the hive and show evident restlessness, the diseased individuals appearing lethargic and putting up no defence when pulled about by their more active sisters.

CAUSE. This form of paralysis is almost certainly a definite disease and can be transmitted from an infected to a healthy bee. The trouble can spread from one colony to another by the drifting of infected individuals. Unfortunately this disease can readily be confused with Type (3) (below) and, apart from experimental inoculation of healthy bees with the blood from diseased individuals, no method of separation is known.

TREATMENT. No satisfactory method of treatment is known and, if the trouble does not disappear after a few weeks it is probably wisest to destroy the colony concerned and so prevent further spread of the disease in the apiary.

(2) **Genetical Type.** SIGNS. Similar to those described for Type (1). In addition bees are found emerging from cells quite hairless. Cases with malformed wings are known.

CAUSE. A hereditary fault in the queen.

TREATMENT. Requeening with a young, healthy, unrelated queen may be expected to effect a complete cure in all cases of this type of paralysis.

(3) **Nitrogen Deficiency Type.** SIGNS. Similar to those described for Type (1).

CAUSE. Anything which upsets the nitrogen metabolism of worker bees. The complaint is not a true disease, in the sense that it is neither infectious nor contagious, and in this country appears most frequently in the early part of the season, but it may break out at any time. It appears to be caused either by prolonged lack of pollen in the hive after brood rearing has become well advanced or, to what is really the same thing, excessive brood rearing continuing during a dearth of natural pollen.

The external skeleton of afflicted bees becomes brittle, so that the individuals concerned lose their hair which easily breaks off, and they may even lose their wings in this way.

TREATMENT. The obvious treatment is to supply the colony concerned with one or more combs of pollen, and it has also been found to be beneficial to give the affected colony one or two combs of emerging brood. It might also be worth while to feed soya bean flour made into a stiff paste with sugar

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Bees in a natural and healthy condition void the faeces when in flight, thus keeping the hive clean. In the autumn and winter there are often long periods of bad weather during which the bees are confined to the hive, and so are unable to take cleansing flights. If, during these periods of inactivity, a bee consumes food containing an excessive amount of indigestible matter, its rectum becomes abnormally distended, and eventually dysentery occurs.

The bee-keeper who delays any artificial feeding that may be necessary until late autumn is courting disaster. At that time of the year the temperature is usually too low for the bees to store and ripen the food properly, and it is likely to become unsuitable for winter consumption. If feeding is necessary, it should be completed in good time. It is much better to winter the bees on their natural, properly ripened and sealed stores of honey. Artificial food should only be given when necessary to supplement their natural food and not as a substitute for it.

Symptoms. Bees affected with dysentery discharge their faeces on the interior walls of the hive, on the combs and on the floorboards. The droppings are usually dark in colour, cloudy in appearance and emit an offensive odour.

Treatment. If a colony not affected with any specific disease develops dysentery, all the combs not covered with bees should be removed; the remaining combs should be closed up with a division board; the interior of the hive and its fittings should be dry; ample ventilation of the hive should be provided; and a cake of candy, or better, if the weather is warm enough for the bees to take it, a rapid feeder of warm concentrated sugar syrup should be put over the cluster of bees and covered with a warm, dry quilt such as a piece of carpet under-felt. Should the bee-keeper have some spare combs containing sealed honey from a healthy source, they should be warmed and given to the bees in preference to either candy or syrup.

POISONING

In fruit-growing districts accidental injury to bees due to spray poison sometimes occurs.

Under orchard conditions arsenic, in the form of lead or calcium arsenate employed in the usual insecticidal and fungicidal spray mixtures, is a source of bee poisoning.

No clear cases of copper or nicotine poisoning have yet been met under field conditions. Indeed arsenical sprays which contain nicotine have been shown to be mildly repellent to bees. Derris and pyrethrum dusts or sprays appear to be relatively harmless to bees, except when they come into direct contact with the bee's body. The danger of poisoning is greatest just before and just after the flowering period. Bees become poisoned in one of two ways: (*a*) by collecting their drinking water from the foliage and trunks of sprayed trees and herbage upon which the spray has drifted; (*b*) by the collection of pollen from plants sprayed while their flowers were open.

In the first type of poisoning the adult bees often die in the field and never regain the hive. In the second type, which is usually very much more serious, few of the bees which collect the contaminated pollen die in the field; the majority regain the hive and both brood and adult bees subsequently become

poisoned by eating this pollen. The pollen quite frequently is not eaten immediately but is stored for some time before use, the resultant poisoning occurring some time after the actual collection of the pollen.

It is often assumed that poison applied to the fruit-blossom is the chief cause of loss, but this is not necessarily so. Severe cases of poisoning are often attributable to poison obtained with pollen from dandelions or other flowers upon which the spray has fallen.

Symptoms. Arsenical poisoning causes partial or complete paralysis, which is first shown by the appearance of numbers of crawlers in front of the hive. The bees tend to congregate on the alighting board and on the ground. The abdomen becomes greatly distended, dysentery appears and the bees die. In cases of poisoning due to the eating of contaminated pollen, older larvae also die and are thrown out of the hive by the surviving bees.

Treatment. Unfortunately, no treatment can be effective once poisoning has actually occurred. The following measures, if followed implicitly, will prevent poisoning occurring even when the colonies of bees are kept in or near an orchard in which arsenical sprays are used:

(1) Add at least 1 per cent of lime sulphur to all spray mixtures which contain arsenic. Lime sulphur is sufficiently repellent to bees to deter them from collecting their drinking water from the foliage and trunks of sprayed trees.

(2) *Never* spray open blossom *of any kind* with mixtures containing arsenic (even if lime sulphur is included, it is not sufficiently repellent to prevent bees from collecting pollen from sprayed flowers). This includes the flowers of weeds, etc.

(3) Make quite sure that the bees have left the trees after petal-fall before applying arsenic. One of the advantages of the honeybee over other insects as a pollinating agent is that she will continue to work, and thus pollinate, flowers from which the petals have been removed prematurely by high winds.

(4) Always see that the bees have a constant supply of clean drinking water in a sheltered place near their hives.

HOW TO SEND SAMPLES OF BEES OR BROOD FOR DISEASE DIAGNOSIS

Adult Bees. Dried-up bees are useless. The bees should preferably be alive, or recently dead. At least 20 bees are required for a diagnosis, and preferably 30 should be sent. Bees showing signs of sickness, as loiterers at the porch, crawlers, etc., form the most useful sample, but if none of these is available the bees may be taken either at the entrance or from the feed-hole.

A match-box or very small tin is the ideal packing, and *no food should be given* or included in the tin or box, for the bees merely get themselves sticky with it. The sample should be despatched as soon as possible after the bees are caught, and the covering letter should *in every instance be sent in the same package as the sample*, and not separately. Number of hive and name and address of sender should be written clearly on the box.

On no account must bees be sent in an envelope only, without a box; they must always be in a box, the latter preferably being packed into a small parcel with brown paper and string.

The covering letter should be short and to the point. A short concise note stating what disease is suspected, whether brood and stores are present (stores in particular are important), and what symptoms have been noticed, will be very useful, but long letters and rambling statements should be avoided. The age of the queen if known, should also be stated.

Brood. Take one of the suspected combs from the hive, preferably one showing brood in all stages *and with a minimum of stores*, brush or shake the adult bees from it, and write your name and the number of the colony on one of the bars of the frame.

Wrap in newspaper, then in corrugated cardboard and finally in stout brown paper tied securely with string. (Special cardboard containers may be available from the secretary of your local association; if so, use one of these: it will save your time and that of the examiner.) If several combs are included in the parcel see that they are separated from one another by folds of newspaper. Place the covering note outside the inner wrapping and *not* in contact with the comb.

Do not send individual larvae removed from their cells; they inevitably dry up in the post, and diagnosis is made needlessly difficult.

If only a portion of comb can be sent, do not enclose it in a tin box; the high humidity in the enclosed space leads to rapid decomposition of the larvae, particularly in hot weather and the sample may be quite unfit for proper diagnosis on arrival.

Shallow or brood combs containing stores only are quite useless for diagnostic purposes and should never be sent.

Bees and combs *when definitely suspected of being diseased* may be sent to the National Agricultural Advisory Service, Rothamsted Lodge, Hatching Green, Harpenden, Herts, where they will be examined and reported upon promptly and free of charge.

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